The Abundance of Benthic Foraminifera in Offshore Sediment Around Pulau Redang, Terengganu

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ABSTRACT

The study on the abundance of benthic foraminifera in offshore sediment was conducted based on twelve bottom samples from the coastal areas of Pulau Redang, Terengganu. Fifty nine species belonging to fifteen families were collected and had been identified. Foraminifera abundance and diversity appears to be principally controlled by sediment texture in the study area. The dominant species is *Amphistegina* cf. *lessonii* and the dominant family is Amphisteginidae. Family which have the most variety of species is Miliolidae with 20 species. Both of *Hauerina* sp. and *Nonion* sp. were found only 1 individual in the study area.

ABSTRAK

Kajian mengenai kelimpahan bentik foraminifera di kawasan perairan luar pantai telah dilakukan berdasarkan duabelas sampel sedimen daripada perairan Pulau Redang, Terengganu. Lima puluh sembilan spesies yang dibawah lima belas famili telah disampel dan dikenalpasti. Kelimpahan dan kepelbagaian foraminifera dilihat lebih dipengaruh oleh tekstur sedimen di kawasan kajian. Spesies yang dominant merupakan Amphistegina *cf.* lessonii *dan kumpulan famili yang dominant adalah Amphisteginidae. Kumpulan famili yang mempunyai kepelbagaian spesies adalah Miliolidae dengan 20 spesies. Kedua-dua* Hauerina *sp. and* Nonion *sp. hanya merekodkan satu individu sahaja di kawasan kajian.*

Keywords: abundance, benthic foraminifera, offshore sediment, Pulau Redang.

Introduction

Foraminifera are testate organisms, which mean that they have shells (tests). The protoplasm covers the exterior of the test. The simplest shapes are tubes or spheres. The tests are divided into chambers; more chambers are added as the cell grows. There are three basic test compositions: organic, agglutinated and secreted calcium carbonate. Foraminifera are single-celled organisms. A distinguishing structure in Foraminifera is the foramen, a hole that connects the wall (septa) between each chamber (Boersma 1980). Foraminifera are aquatic organisms, found in both freshwater and marine environments. For example, *Amphistegina gibbosa* inhabit coral reefs and carbonate shelves. Species diversity is highest in tropical areas. Foraminifera are the most prevalent benthic organisms in deep-sea fossil records, but some are planktic. There are many characteristics which influence foraminifera distribution, such as sediment type, food availability, oxygen levels and hydrostatic pressure. However, species can tolerate a wide range of unfavourable conditions. Low concentrations of foraminifera in benthic regions may indicate an environment under stress (Haynes 1981).

Study Area

Pulau Redang, Terengganu is located on the northern of South China Sea. A total of twelve sediment samples were collected from twelve sampling stations in Pulau Redang, Terengganu between 05°43ô15ò to 05°45ô50ò'N and 102°59ô09ò to 103°03ô05òE (Fig. 1). The range of salinity in the study area is between 25 to 34 ppt. The maximum value of dissolve oxygen is 7.03 mg/L at St 6 while the minimum value is 6.37 mg/L at St 2. In the study area, the highest temperature is noted at St 11 with 30.68°C and the lowest was 20.10°C at St 1. The sediment textures in the study area are classified as sand, loamy sand and sandy loam.

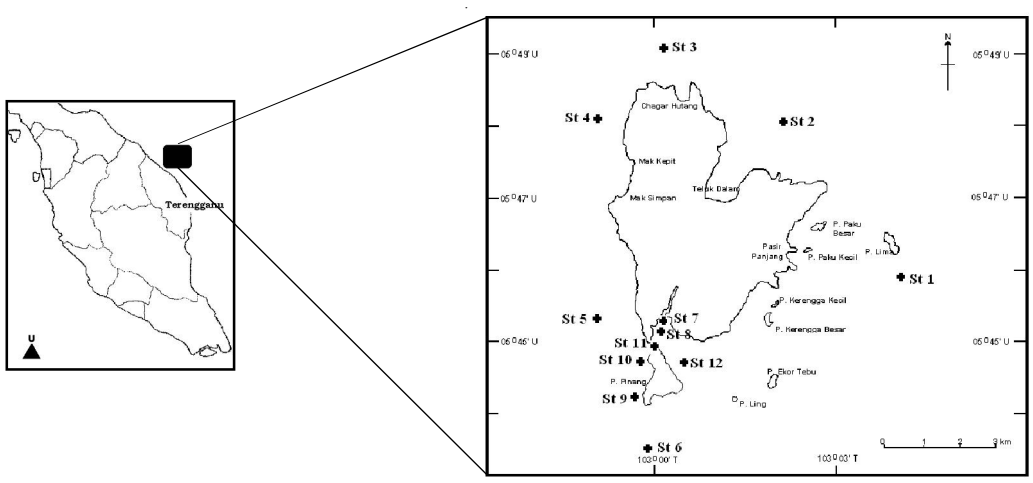

FIGURE 1: Map of Sampling Stations in Pulau Redang

Materials and Methods

On July 2002, sediment samples were colleted from twelve sampling stations in Pulau Redang, Terengganu with Petite Ponar type of grab sampler. The samples were used for identification process and physico-chemical analysis. The preparation of foraminifera samples was conducted by the method of wet filtration washings (Sohn et al. 1965). In the laboratory, each of the samples used for identification process was washed through a series of sieves (0.600, 0.180 and 0.063 mm). The samples were preserved in formalin and later stained with Rose Bengal for estimating the percentage of foraminifera species collected alive. Foraminifera specimens were classified as living specimen if they were judged to have been alive at the time of collection that had both strongly and slightly Rose Bengal coloured valves. Specimens were classified as dead if they had partly preserved. All specimens were picked up from the dried sediment. A number of systematic of quantitative analysis were applied to the faunal analysis including the simple species diversity (number of species in each sample), abundance (specimen number in each sample) and dominance (percentage of the most abundant species in each sample) have been ascertained in order to elucidate the nature of the various foraminifera communities and their relationship with the environmental factors. The species were identified with Scanning Electron Microscope (SEM) in SEM Unit, Faculty of Science and Technology, Universiti Kebangsaan Malaysia. Several *in-situ* physico-chemical parameters such as temperature, salinity, dissolve oxygen, percentage of organic matter and sediment texture were measured and had been determined in the laboratory.

TABLE 1: The Coordinate, Temperature, Dissolve Oxygen, Salinity, Organic Matter, Sediment Texture, Number of Species and Total of Foraminifera for Every Sampling Station

St	Coordinate	Tempe-rature, °C	Dissolve oxygen, mg/L	Salinity, ppt	Organic matter, (%)	Sediment texture	No. of species	Total of. Foraminifera
1	05°45ô50N, 103°03ô05E	20.00	6.48	31.22	1.67	Loamy sand	16	4926
2	05°45ô50N, 103°03ô05E	25.00	6.37	32.33	1.53	Sand	19	7126
3	05°49ô12N, 103°00ô15E	26.66	6.50	31.11	3.32	Loamy sand	24	3716
4	05°48ô22N, 102°59ô09E	30.00	6.92	28.04	3.10	Sandy loam	24	2412
5	05°45ô36N, 102°59ô09E	27.00	6.70	34.00	6.01	Sandy loam	28	3739
6	05°43ô15N, 102°59ô55E	25.00	7.03	30.35	1.66	Sand	28	2935
7	05°45ô24N, 103°00ô11E	29.00	6.92	30.00	5.47	Sandy loam	25	2623
8	05°45ô15N, 103°00ô07E	25.00	6.71	30.26	4.09	Sand	21	928
9	05°44ô29N, 102°59ô58E	30.10	6.75	30.25	2.54	Sand	16	492
10	05°44ô48N, 102°59ô57E	29.87	6.84	30.43	3.27	Sand	15	413
11	05°45ô07N, 103°00ô02E	30.68	6.82	30.52	2.13	Sand	20	5075
12	05°44ô58N, 103°00ô34E	30.51	6.87	30.62	1.82	Sand	20	4703

Results and Discussion

Foraminifera Abundance

A total of 39082 individual from 15 families, 26 genera and 59 species were found and identified in offshore sediment around Pulau Redang, Terengganu from the entire set of 12 samples. The families are Miliolidae, Amphisteginidae, Calcarinidae, Discorbidae, Elphidiidae, Globigerinidae, Reophacidae, Nodosariidae, Nubeculariidae, Nummulitidae, Planorbulinidae, Rotaliidae, Soritidae, Cymbaloporidae and Textularidae. The faunal assemblage is dominated by Amphisteginidae family with 20966 individual (average abundance %). The second family is Miliolidae (14.70%), followed by Nummulitidae (9.19%), Rotaliidae (8.81%), Elphidiidae (3.94%), Calcarinidae (3.12%), Nubeculariidae (2.85%), Textularidae (1.47%), Soritidae (1.27%), Planorbulinidae (0.85%), Reophacidae (0.14%), Cymbaloporidae (0.02%), Discorbidae (0.005%), Globigerinidae (0.005%) and Nodosaridae (0.003%). Family with have the most variety of species is Miliolidae with 20 species. There are *Quinqueloculina* sp. (A), *Quinqueloculina* sp. (B), *Quinqueloculina psuedoreticulata*, *Quinqueloculina parkeri*, *Quinqueloculina philippinensis*, *Quinqueloculina seminulum*, *Quinqueloculina simplex*, *Quinqueloculina tropicalis*, *Quinqueloculina curta*, *Quinqueloculina sulcata*, *Triloculina tricarinata*, *Triloculina trigonula*, *Triloculina* cf. *oblonga*, *Triloculina* sp., *Pyrgo* cf. *constricta*, *Pyrgo* sp., *Adelosina semistriata*, *Psuedomassilina medioelata*, *Miliolinella* sp. and *Hauerina* sp. The dominant species is *Amphistegina* cf. *lessonii* with 16498 individuals. The abundance of foraminifera were maximum at St 2 (7120 individuals) and minimum at St 10 (413 individuals). Both *Hauerina* sp. and *Nonion* sp. were found only 1 individual. Most of foraminifera were found lived in sand sediment.

Taxonomy

All collection is stored at School of Environment and Natural Resource Sciences, Faculty of Science and Technology, Universiti Kebangsaan Malaysia. We refer to the taxonomy provided by Whittaker & Hodgkinson 1979, Haynes 1973 and Cushman 1969.

Family **NUBECULARIDAE** Jones 1875
Genus ***Spiroculina*** dôOrbigny 1826
Spiroloculina communis Cushman & Todd 1944

1921 *Spiroloculina grateloupi* dôOrbigny, p. 397, pl. 78, fig. 5
1944 *Spiroloculina communis* Cushman & Todd, p. 64, pl. 9, figs 1-3, 6
1951 *Spiroloculina communis* incisa Cushman & Asano, p. 13, figs. 89, 90
1979 *Spiroloculina communis* Whittaker & Hodgkinson, p. 21, pl. 1, fig. 5

Remarks: The holotype appears to be a very large individual, about 3.7 mm long. This specimen are similar with *S. communis* from Togopi formation, eastern Sabah, Malaysia (Whittaker & Hodgkinson, 1979) and differs with *S. communis* (Cushman & Todd) in having the peripheral margins of the chambers raised above the succeeding chambers.

Spiroloculina eximia Cushman 1922
Pl. 1, fig. 20

1922 *Spiroloculina eximia* Cushman, p. 61, pl. 11, fig. 2
1929 *Spiroloculina eximia* Cushman, p. 42, pl. 8, figs. 7a, b
1944 *Spiroloculina eximia* Cushman & Todd, p. 46, pl. 6, figs. 36a-38b
1956 *Spiroloculina eximia* Cushman & Bhatia, p. 18, pl. 1, figs. 14a, b
1979 *Spiroloculina eximia* Whittaker & Hodgkinson, p. 21, pl. 1, fig. 6

Remarks: This species was found in the recent tropical western Pacific, west coast of India. It was originally described from the Tortugas, off Florida, though further records from the Caribbean appear to be lacking. The Togopi specimens are believed to constitute the first fossil record.

Spiroculina lucida Cushman & Todd 1944

1944 *Spiroculina lucida* Cushman & Todd, p. 70, pl. 9, figs. 30-31b
1951 *Spiroculina lucida* Cushman et al., p. 15, figs. 99, 100
1956b *Spiroculina lucida* Cushman et al., p. 68, pl. 7, figs. 5a, b
1979 *Spiroculina lucida* Whittaker & Hodgkinson, p. 21, pl. 1, fig. 7

Remarks: The peripheral margins of the older chambers always project to form weak ridges. The main difference between *S. lucida* and *S. communis* is that in typical members of the latter group the periphery is flat or more commonly concave, while in the former is convex.

Spiroloculina manifesta Cushman & Todd 1944
Pl. 1, fig. 8

1921 *Spiroloculina canaliculata* dôOrbigny, Cushman, p. 395, pl. 80, figs. 3a, b
1944 *Spiroloculina manifesta* Cushman & Todd, p. 62, pl. 8, figs. 26a-28
1951 *Spiroloculina manifesta* Cushman et al., p. 15, figs. 101, 102
1979 *Spiroloculina manifesta* Whittaker & Hodgkinson, p. 21, pl. 1, figs. 8, 9

Remarks: Considerable morphological variation exists within the Togopi specimens. The microspheric form tends to be subcircular in side view with the chambers nearly flush; the megalospheric form, on the other hand, is much narrower and often strongly concave in the central portion of the test.

Family **MILIOLIDAE** Ehrenberg 1839
Genus ***Quinqueloculina*** dôOrbigny 1826

Quinqueloculina curta Cushman 1921

1921 *Quinqueloculina curta* Cushman, p. 426, pl. 100, figs. 1, 2
1931 *Quinqueloculina curta* Cushman & Hada, p. 80, figs. 33a-c
1937 *Quinqueloculina curta* Cushman et al., p. 114, pl. 17, figs. 1, 4
1941 *Quinqueloculina curta* Cushman & Le Roy, p. 113, pl. 1, figs. 1-5

TABLE 4: The Distribution of Benthic Foraminifera Species in Pulau Redang, Terengganu

FAMILI	SPESIES	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12
Miliolidae	*Quinqueloculina* sp. (A)	0	0	4	8	8	11	15	34	121	19	1463	1365
	Triloculina tricarinata	0	10	25	0	15	0	12	0	17	45	514	183
	Pyrgo cf. constricta	0	0	2	1	0	0	0	0	0	0	0	0
	Quinqueloculina psuedoreticulata	0	23	0	201	210	244	162	0	0	0	0	0
	Quinqueloculina parkeri	21	0	11	0	17	0	0	0	0	0	0	0
	Quinqueloculina philippinensis	0	0	0	30	55	0	12	0	0	0	0	0
	Psuedomassilina medioelata	0	8	8	0	11	0	0	0	0	0	0	0
	Quinqueloculina simplex	0	0	0	0	0	10	0	0	0	0	0	0
	Quinqueloculina tropicalis	0	0	0	5	2	0	0	0	0	0	0	0
	Triloculina trigonula	38	34	47	140	39	92	0	0	0	0	0	0
	Adelosina semistriata	0	0	0	4	0	0	0	0	0	0	0	0
	Quinqueloculina sp. (B)	0	0	0	0	2	5	0	0	0	0	0	0
	Pyrgo sp.	0	0	0	0	0	0	6	0	0	0	0	0
	Miliolinella sp.	0	0	0	0	0	0	7	0	0	0	0	0
	Hauerina sp.	0	0	0	0	0	0	1	0	0	0	0	0
	Triloculina cf. *oblonga*	0	0	0	0	0	0	21	0	0	0	0	0
	Triloculina sp.	0	0	0	0	0	0	30	14	5	0	8	0
	Quinqueloculina curta	0	0	0	0	0	0	240	0	0	0	0	0
	Quinqueloculina seminulum	0	0	0	0	0	0	21	0	0	0	0	0
	Quinqueloculina sulcata	0	0	0	0	0	0	90	0	0	0	0	0
Rotaliidae	*Asterorotalia pulchella*	15	0	115	11	15	39	3	0	0	0	0	0
	Ammonia nipponica	0	0	19	0	0	0	0	0	0	0	0	0
	Ammonia indica	0	0	0	0	7	94	0	0	0	0	0	0
	Ammonia beccarii	0	2	0	350	689	349	285	180	8	3	9	195
	Cavarotalia annectens	0	0	0	264	205	0	0	0	0	0	0	0
	Psuedorotalia schroeteriana	0	2	0	186	21	0	0	0	0	0	0	0
	Asterorotalia inspinosa	0	0	0	0	0	0	123	5	2	0	3	2
	Pararotalia calcar	0	0	0	0	0	0	0	150	17	32	18	24
Cymbaloporidae	*Cymbaloporella taballaeformis*	0	0	0	0	0	0	0	2	3	0	0	1
Nummulitidae	*Operculina ammonoides*	61	567	228	181	1287	67	1077	3	3	1	11	28
	Operculina sp.	54	7	11	0	0	0	0	0	0	0	0	0
Nubeculariidae	*Spiroloculina manifesta*	8	5	0	22	28	6	99	4	0	2	254	18
	Spiroloculina eximia	0	0	0	21	17	0	39	3	0	1	21	9
	Spiroloculina communis	12	3	0	0	84	8	0	0	0	0	0	0
	spiroloculina excisa	0	0	0	0	0	0	30	5	0	0	168	13
	Spiroloculina lucida	0	0	0	0	0	0	3	2	0	0	15	2
	Spiroloculina sp.	0	0	0	0	0	0	48	11	1	4	173	23
Amphisteginidae	*Amphistegina lobifera*	1073	579	217	68	41	71	0	0	0	0	0	0
	Amphistegina cf. *lessonii*	3460	5720	1919	621	189	1613	20	153	79	102	1266	1356
	Amphistegina wanneriana	0	0	0	0	0	0	40	114	74	50	987	1154
Calcarinidae	*Calcarina calcar*	0	0	610	0	0	0	0	0	0	0	0	0
	Calcarina hispida	0	0	113	0	0	6	0	25	84	18	10	19
	Calcarina sp.	26	8	46	8	0	3	0	25	71	133	8	5
Ephidiidae	*Ephidium hispidulum*	14	10	45	56	179	25	87	45	1	1	3	2
	Cellanthus biperforatus	24	12	85	101	491	36	200	98	2	1	13	9
Textulariidae	*Textularia psuedogramen*	0	20	11	0	25	77	0	0	0	0	0	0
	Textularia stricta	0	0	0	3	8	17	0	0	0	0	0	0
	Textularia goesii	49	44	93	34	31	10	0	0	0	0	0	0
	Textularia sp. (A)	0	0	1	0	8	24	0	0	0	0	0	0
	Textularia sp. (B)	18	6	20	54	20	0	0	0	0	0	0	0
Reophacidae	*Reophax* sp. (A)	0	0	0	0	0	9	0	0	0	0	0	0
	Reophax sp. (B)	0	0	0	8	35	3	0	0	0	0	0	0
Discorbidae	*Cibicides lobatulus*	0	0	1	0	0	1	0	0	0	0	0	0
Nodosariidae	*Nonion* sp.	0	0	0	0	0	1	0	0	0	0	0	0
Soritidae	*Peneroplis planatus*	1	0	16	0	0	1	0	15	2	0	72	227
Peneroplis	*pertusus*	0	0	0	0	0	0	0	38	0	1	59	65
Globigerinidae	*Globigerinita glutinata*	0	1	0	0	0	1	0	0	0	0	0	0
Planorbulinidae	*Planorbulinella larvata*	52	59	69	35	0	112	0	2	2	0	0	3

1959 *Quinqueloculina curta* Cushman et al., p. 44, pl. 5, figs. 9a-c
1963 *Quinqueloculina curta* Cushman & Matsunaga, pl. 26, figs. 16a-c

Remarks: The specimens is smooth with rounded chambers, carinate being only poorly developed on the chamber peripheries, to forms with truncate, strongly carinate peripheries and even secondary reticulate ornament.

Quinqueloculina parkeri Brady 1917
Pl. 1, fig. 13

1917 *Quinqueloculina parkeri* Brady & Cushman, p. 50, pl. 15, figs. 3a-c
1932 *Quinqueloculina parkeri* Brady & Cushman, p. 25, pl. 6, figs. 3, 4
1957 *Quinqueloculina parkeri* Brady & Todd, p. 286, pl. 85, figs. 13a-14b
1961 *Quinqueloculina parkeri* Brady & Huang, p. 85, pl. 1, fig. 24
1963 *Quinqueloculina parkeri* Brady & Matsunaga, pl. 28, figs. 7a-c
1965 *Quinqueloculina parkeri* Brady & Moura, p. 17, pl. 1, fig. 13
1968 *Quinqueloculina parkeri* Brady et al., p. 110, pl. 9, figs. 4a-b

Remarks: The chamber peripheries are angled and truncate. The ornament is generally well developed on the earlier visible chambers but is often sparse or absent over the last chamber, particularly in the apertural region.

Quinqueloculina philippinensis Cushman 1974
Pl. 1, fig. 27

1917 *Quinqueloculina reticulata* Cushman, p. 55, pl. 16, fig. 1
1936 *Quinqueloculina thalmanni* Vroman, p. 422, figs. 1-5
1959 *Triloculina kerimbatica* (Heron-Allen & Earland) var. philippinensis (Cushman), p. 112, pl. 1, figs. 20-22
1968 *Quinqueloculina kerimbatica* (Heron-Allen & Earland), p. 18, pl. 3, figs. 12-15
1974 *Quinqueloculina philippinensis* Cushman, Ponder, p. 244, pl. 13, figs. 22, 23

Remarks: The early chambers of this species are very prominent and well developed apertural neck is very characteristic. Ornament is relatively coarse reticulum and there is some degree of ribbing.

Quinqueloculina psuedoreticulata Parr, 1941
Pl. 1, fig. 28

1941 *Quinqueloculina reticulata* (dôOrbigny), Le Roy, p. 22, pl. 3, figs. 1-3
1958 *Quinqueloculina reticulata* (dôOrbigny), Ganapati & Satyavati, pl. 2, fig. 32
1964 *Quinqueloculina psuedoreticulata* Parr, Rocha & Ubaldo, p. 38, pl. 2, fig. 7
1967 *Quinqueloculina psuedoreticulata* Parr, Lloyd, p. 88, pl. 13, figs. 5a-c
1968 *Quinqueloculina psuedoreticulata* (dôOrbigny), Chiji & Lopez, p. 110, pl. 9, figs. 5a-c

Remarks: The reticulate ornament is confined predominantly to the peripheral surface of each chamber, the central part of each face being smooth. In larger specimen the chamber

edges are broadly rounded, while in smaller specimens they are more acute. It produced apertural neck and coarser ornamentation of *Q. philippinensis*.

Quinqueloculina sulcata dôOrigny, 1826

1826 *Quinqueloculina sulcata* dôOrigny, p. 301, no. 17
1900 *Quinqueloculina sulcata* dôOrigny, Fornasini, p. 364, fig. 9
1932 *Quinqueloculina sulcata* dôOrigny, Cushman, p. 28, pl. 7, figs. 5-8c
1954 *Quinqueloculina sulcata* dôOrigny, Cushman, Todd & Post, p.334, pl. 84, figs. 1,2
1968 *Quinqueloculina sulcata* dôOrigny, Chiji & Lopez, p. 110, pl. 9, figs. 7a, b
1979 *Quinqueloculina sulcata* Whittaker & Hodgkinson, p. 29, pl. 2, fig. 7

Remarks: It has been recorded in the Recent of the Red Sea (dôOrbigny, 1826), Fiji (Cushman, 1932), Marshall Islands, west Pacific (Cushman, Todd & Post, 1954), Japan (Chiji & Lopez, 1968) and eastern Sabah, Malaysia (Whittaker & Hodgkinson, 1979).

Genus ***Psuedomassilina*** Lacroix, 1983
Psuedomassilina medioelata Whittaker & Hodgkinson, 1979
Pl. 1, fig. 6

1979 *Psuedomassilina medioelata* Whittaker & Hodgkinson, p. 29, pl. 2, figs. 15, 16

Remarks: This specimens had fully developed show the typical flattened planispiral chambers of a *Psuedomassilina*. It have stronger, thicker tests and are ornamented by well developed costae.

Genus ***Triloculina*** dôOrbigny, 1826
Triloculina trigonula Lamrack, 1826
Pl. 1, fig. 23

1826 *Triloculina trigonula* (Lamrack), dôOrbigny, p. 299, pl. 16, figs. 5-9
1941 *Triloculina trigonula* (Lamrack), Le Roy, p. 22, pl. 3, figs. 26-28
1955 *Triloculina trigonula* (Lamrack), Takayanagi, pl. 1, fig. 14
1963 *Triloculina trigonula* (Lamrack), Matsunaga, pl. 30, figs. 2a, b
1968 *Triloculina trigonula* (Lamrack), Bhalla, p. 382, pl. 1, figs. 2a, b
1970 *Triloculina trigonula* (Lamrack), Matoba, p. 62, pl. 3, figs. 3a, b

Remarks: The fossil of this species was originally described from the Eocene of France. In Recent, a cosmopolitan species frequently found throughout the Indo-Pacific region at the present day.

Triloculina tricarinata dôOrbigny, 1865

1865 *Triloculina tricarinata* dôOrbigny, Parker, Jones & Brady, p. 34, pl. 1, fig. 8
1932 *Triloculina tricarinata* dôOrbigny, Cushman, p. 59, pl. 13, figs. 3a, b
1956 *Triloculina tricarinata* dôOrbigny, Bhatia, p. 19, pl. 1, figs. 16a, b
1961 *Triloculina tricarinata* dôOrbigny, Braga, p. 77, pl. 7, figs. 3, 4

1965 *Triloculina tricarinata* dôOrbigny, Moura, p. 26, pl. 3, fig. 2
1969 *Triloculina tricarinata* dôOrbigny, Rao, p. 592, pl. 3, fig. 22

Remarks: The chamber sides of this species are rarely straight to gently concave. It has been reported on a number of occasions from both the west and east coasts of the Indian subcontinent and Sri Lanka. Other records in the region comprise the Red Sea and Mozambique.

Family **SORITIDAE** Ehrenberg, 1839
Genus ***Peneroplis*** de Montfort, 1808
Peneroplis planatus Fichtel & Moll, 1898

1959 *Peneroplis discoideus* Flint, Graham & Militante, p. 62, pl. 9, fig. 22
1979 *Peneroplis planatus* Whittaker, Hadgkinson, p. 75, pl. 8, fig. 8

Remarks: The specimens have a striate ornament and don't developed subepidermal partitions even in the final chambers. This species had previously recorded in Recent of north ï central Philippines and of the Togopi formation, eastern Sabah, Malaysia.

Family **ROTALIIDAE** Ehrenberg, 1839
Genus ***Ammonia*** Brunnich, 1772
Ammonia beccarii Cushman, 1963
Pl. 1, fig. 4

1963 *Ammonia cf. beccarii* Cushman, Ujiie, pl. 2, figs. 7a-c
1964 *Ammonia hozanensis* Nakamura, Huang, p. 53, pl. 1, figs. 4a-c
1967 *Ammonia beccarii tepida* Cushman, Konda, p. 33, pl. 4, figs. 9a, b
1968 *Ammonia beccarii tepida* Cushman, Chiji, p. 58, pl. 3, figs. 4a, b

Remarks: This species show varying degrees of chamber inflation in the final whorl. The earlier sutures, however are limbate and flush. The umbilical depression is usually somewhat in filled with secondary material but is not plugged. It distributed in the tropical waters of the Indo-Pacific.

Genus ***Asterorotalia*** Hofker, 1951
Asterorotalia pulchella dôOrbigny, 1951
Pl. 1, figs. 9, 33

1927 *Rotalia pulchella* dôOrbigny, Hofker, p. 37, pl. 16, figs. 7-10
1937 *Rotalia trispinosa* Thalman, Yabe & Asano, p. 103, pl. 18, fig. 11
1951 *Asterorotalia pulchella* dôOrbigny, Hofker, p. 505, figs. 343, 344
1958 *Asterorotalia pulchella* dôOrbigny, Reiss & Merling, pl. 2, figs. 2, 3; pl. 5, figs. 12, 13
1964 *Asterorotalia trispinosa* Thalman, Le Roy, p. F39, pl. 6, figs. 18, 19

Remarks: *Asterorotalia pulchella* becomes plentiful and the ornament on the dorsal surface varies from very sparse to heavy o n both chambers and sutures. It appears to be confined in eastern Sabah to Indonesia and the coasts of India.

Genus ***Pararotalia*** Le Calvez, 1949
Pararotalia calcar dôOrbigny, 1970

1884 *Rotalia calcar* dôOrbigny, Brady, p. 709, pl. 108, figs. 3a-c
1927 *Rotalia calcar* dôOrbigny, Hofker, p. 37, pl. 17, figs 1-13
1946 *Calcarina calcar* dôOrbigny, Germeraad, p. 70, pl. 4, fig. 1
1954 *Rotalia calcar* dôOrbigny, Kleinpell, p. 61, pl. 7, figs. 5, 6
1964 *Calcarina calcar* dôOrbigny, Rocha & Ubaldo, p. 153, pl. 19, figs. 5-7
1970 *Pararotalia calcar* dôOrbigny, Hofker, p. 55, pl. 41, figs. 1-5

Remarks: These specimens are placed in *Pararotalia* as they have laterally elongated chambers, a plugged umbilicus and an interiomarginal and curved intercameral aperture. Ornament is variable and consists of pustules, particularly over the umbilical area, hyaline ridges along the chambers and hispid spines.

Genus ***Psuedorotalia*** Reiss & Merling, 1958
Psuedorotalia schroeteriana Parker & Jones, 1958
Pl. 1, fig. 32

1937 *Rotalia schroeteriana* Parker & Jones, Yabe & Asano, p. 104, pl. 19, fig. 10
1958 *Psuedorotalia schroeteriana* Parker & Jones, Reiss & Merling, p. 13, pl. 1, figs. 15-17
1968 *Psuedorotalia schroeteriana* Parker & Jones, Hofker, p. 30, pl. 10, figs. 4-18
1971 *Psuedorotalia schroeteriana* Parker & Jones, Hofker, p. 31, pl. 73, figs. 1-6

Remarks: Microspheric form of this specimens have a flat spiral and a high conical umbilical side with single or double rows of beading along the sutures. The umbilical plug is added to the apex of the newest chamber but because of the high conical test shape the plug development on earlier chambers remains prominent, simulating a lateral displacement, whereas it is in reality terminal in relation to each chamber.

Family **CALCARINIDAE** Schwager, 1876
Genus ***Calcarina*** dôOrbigny, 1826
Calcarina hispida Brady, 1884
Pl. 1, fig. 5

1884 *Calcarina hispida* Brady, p. 713, pl. 108, figs. 8, 9
1921 *Calcarina hispida* Brady, Cushman, p. 356, pl. 75, fig. 4
1954 *Calcarina hispida* Brady, Cushman, Todd & Post, p. 363, pl. 90, figs. 9-12
1961 *Calcarina hispida* Brady, Huang, p. 88, pl. 5, figs. 1-4
1970 *Calcarina hispida* Brady, Hofker, p. 63, pl. 43, figs. 5-13
1979 *Calcarina hispida* Brady, Whittaker & Hodgkinson, p. 73, pl. 7, figs. 1, 2

Remarks: The chambers in the last whorl are prominent or obscure, while in across section the test varies in its biconvexity, the chamber peripheries being either rounded or acute. The spines never more than nine, arise at any angle along a suture and are always hispid. The strongly biconvex forms are usually heavily postulate and very hispid but

flatter specimens with prominent chambers in the last whorl have reduced ornament, what pustules there are being confined to the umbilical region.

Family **ELPHIDIIDAE** Galloway, 1933
Genus ***Cellanthus*** de Montfort, 1808
Cellanthus biperforatus Whittaker & Hodgkinson, 1979
Pl. 1, fig. 22

1979 *Cellanthus biperforatus* Whittaker & Hodgkinson, p. 73, pl. 7, figs 3a, b

Remarks: Test calcareous, perforate, biconvex and plugged. Plug raised, translucent, occupying a third of the test diameter and perforated by many canals. Periphery round in side view. On the later-formed sutures the anterior pores are larger than the posterior row, but for the most part are of the same size. Test inflated in apertural view, peripheries subrounded.

Family **NUMMULITIDAE** de Blainville, 1825
Genus ***Operculina*** dôOrbigny, 1826
Operculina ammonoides Schroter, 1783
Pl. 1, fig. 2

1783 *Nautilus ammonoides* Schroter, p. 21
1893 *Operculina ammonoides*, (Gronovius), Egger, p. 242, pl. 20, figs. 38, 39
1939 *Operculina ammonoides* (Gronovius), Hanzawa, p. 229, pl. 15, figs. 1a-2b
1959 *Operculina ammonoides* (Gronovius), Graham & Militante, p. 76, pl. 12, figs. 1, 2
1961 *Operculina ammonoides* (Gronovius), Huang, p. 86, pl. 3, figs. 22, 23
1964 *Operculina ammonoides* (Gronovius), Rocha & Ubaldo, p. 156, pl. 19, fig. 13

Remarks: This specimens show gradation from thin, almost evolute test with a strong marginal cord, to thick, nearly in volute immature tests but never completely involute. The megalospheric generation remains close-coiled but the microspheric has a flared last whorl, have a coarsely postulate umbilical area with a large central umbonal pustule.

Family **GLOBIGERINIDAE** Carpenter, Parker & Jones, 1862
Genus ***Globigerinita*** Bronnimann, 1951
Globigerinita glutinata Egger, 1893

1893 *Globigerinita glutinata* Egger, p. 371, pl. 13, figs. 19-21
1979 *Globigerinita glutinata* (Egger), Whittaker & Hodgkinson, p. 75, pl. 8, fig. 13

Remarks: This species was recorded by F. L. Parker (1967) as G. glutinata (Egger) with range of late Miocene to Recent and Togopi formation, eastern Sabah, Malaysia.

Family **AMPHISTEGINIDAE** Cushman, 1927
Genus **Amphistegina** dôOrbigny, 1826
Amphistegina cf. *lessonii* dôOrbigny, 1826
Pl. 1, fig. 11

1826 *Amphistegina cf. lessonii* dôOrbigny, p. 304, pl. 17, figs. 1-4
1979 Amphistegina cf. lessonii (dôOrbigny), Whittaker & Hodgkinson, p. 75, pl. 8, fig. 2

Remarks: This species occurs in all but the highest samples in the Pulau Redang, Terengganu. *A.* cf. *lessonii* was recorded in Togopi formation, eastern Sabah, Malaysia.

Family **PLANORBULINIDAE** Schwager, 1877
Genus ***Planorbulinella*** Cushman, 1927
Planorbulinella larvata Parker & Jones, 1865

1865 *Planorbulinella larvata* Parker & Jones, pp. 379, 380, pl. 19, figs. 3a, b
1969 *Planorbulinella larvata* (Parker & Jones), Freudenthal, p. 82, pl. 4, figs. 3, 4
1979 *Planorbulinella larvata* (Parker & Jones), Whittaker & Hodgkinson, p.101, figs. 65a-b

Remarks: This species is commonly occurring in the Indian and Pacific Oceans and in the Red Sea. There appear to be several reliable records as early as the Miocene and was recorded in Togopi formation, eastern Sabah, Malaysia.

Conclusion

From this study, it showed that the benthic foraminifera are abundance and have a variety of species. A total of 39,082 specimens had been identified as 59 species from 15 families. *Amphistegina* cf. *lessoni* is the most dominant spesies with 16,498 individuals. While the most dominant family is Amphisteginidae with 20,966 individuals. Family with have the most variety of species is Miliolidae with 20 species. Both of *Hauerina* sp. and *Nonion* sp. were found only 1 individual in the study area. The abundance of foraminifera were maximum at Station 2 (7120 individuals) and minimum at Station 10 (413 individuals). Most of foraminifera were found in sand dominated sediment.

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References

Boersma, A. 1980. Foraminifera. In. Haq, B. U. & Boersma, A. (eds.) *Introduction to Marine Paleontology*. London: Graham & Trotman Limited.

Cushman, J. A. 1969. *Foraminifera: Their classification and economic use*. Cambridge: Harvard University Press.

Doyle, P. 1996. *Understanding fossils: An Introduction to Invertebrate Palaeontology*. England: John Wiley & Sons.

Haynes, J. R. 1973. Cardigan Bay Recent Foraminifera. *Bulletin of the British Museum* (Natural History).

Haynes, J. R. 1981. *Foraminifera*. London: Macmillan Publishers Limited.

Whittaker, J. E. & Hodgkinson, R. L. 1979. Foraminifera of the Togopi Formation, eastern Sabah, Malaysia. *Bulletin of the British Museum* (Natural History).

Plate 1

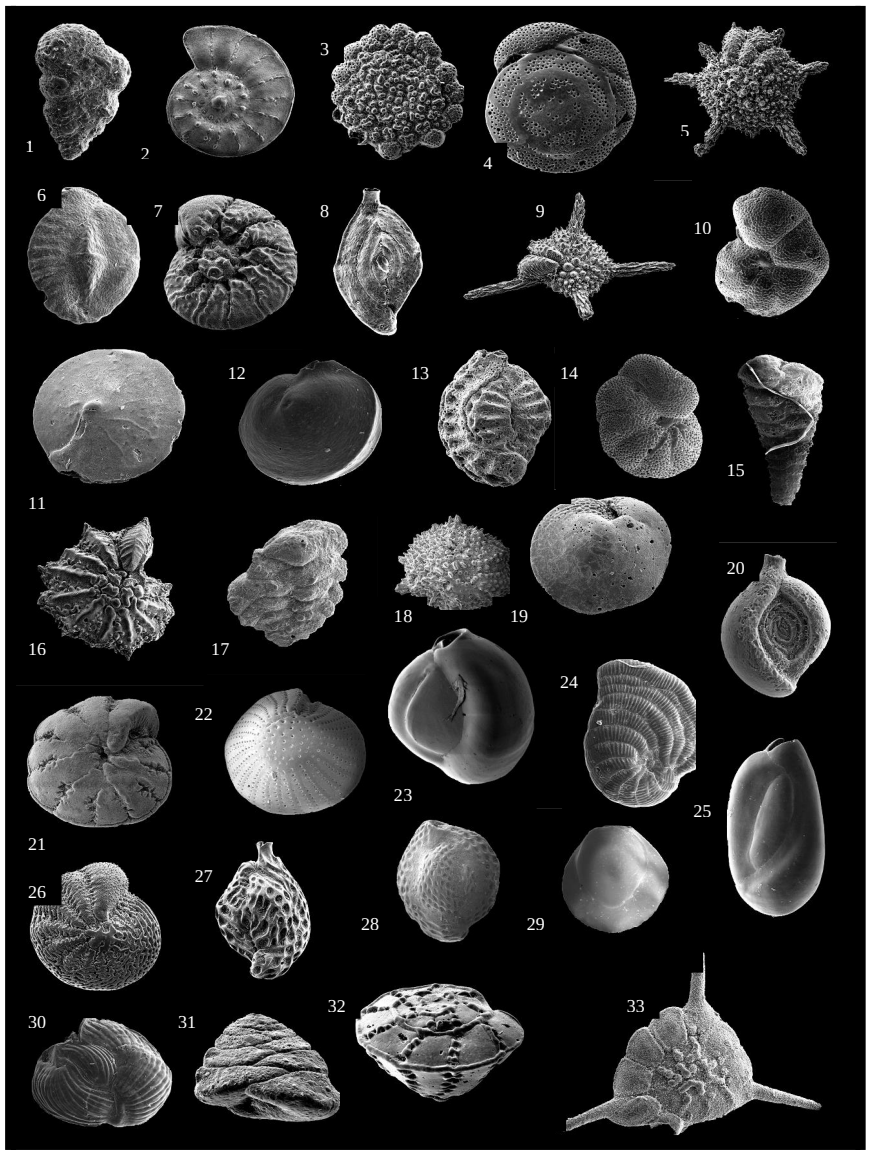

Plate 1

1. *Textularia* sp. (A), **2.** *Operculina ammonoides*, **3.** *Planorbulinella rubra*, **4.** *Ammonia beccarii*, **5.** *Calcarina hispida*, **6.** *Pseudomassilina medioelata*, **7.** *Ammonia nipponica*, **8.** *Spiroloculina manifesta*, **9.** *Asterorotalia pulchella*, **10.** *Cibicides lobatulus*, **11.** *Amphistegina* cf. *lessonii*, **12.** *Adelosina semistriata*, **13.** *Quinqueloculina parkeri*, **14.** *Nonion* sp., **15.** *Textularia stricta*, **16.** *Calcarina calcar*, **17.** *Textularia* sp. (B), **18.** *Calcarina* sp., **19.** *Amphistegina lobifera*, **20.** *Spiroloculina eximia*, **21.** *Ammonia indica*, **22.** *Cellanthus biperforatus*, **23.** *Triloculina* cf. *trigonula*, **24.** *Peneroplis planatus*, **25.** *Quinqueloculina tropicalis*, **26.** *Elphidium hispidulum*, **27.** Quinqueloculina philippinensis, **28.** Quinqueloculina pseudoreticulata, **29.** Pyrgo cf. constricta, **30.** *Quinqueloculina* sp. (B), **31.** *Quinqueloculina* sp. (B), **32.** *Textularia goesii*, **32.** *Pseudorotalia Schroeteriana,* and **33.** *Asterorotalia pulchella*